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EASTERN TREE SEED LABORATORY

21st & 22nd Reports 1977~1980

Dedicated To Service And Assistance In Forest Regeneration

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PART I

TWENTY-FIRST LABORATORY REPORT

Fiscal Years 1977 and 1978

By

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Operated in cooperation with:

Southeastern Area, State and Private Forestry and the Southern Forest Experiment Station, U.S. Forest Service; Georgia Forestry Commission; and the Georgia Forest Research Council.

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INTRODUCTION

In 1978, the Eastern Tree Seed Laboratory entered its 25th year of cooperative support service to forest nursery and seed orchard managers. The increased demands on the present services have not permitted an in-depth evaluation of the first 25 years. However, an evaluation of selected periods as well as a complete evaluation of the past 2 years is presented in this report. Additional notes of interest and current publications are also presented.

SERVICE TESTING

In recent years there have been many personnel changes at the nurseries, seed plants and in the tree seed orchards. For the benefit of these new people some reoccurring situations have been selected for presentation to help the reader better understand and use the services of the seed laboratory.

Reporting Full Seed Percent

Occasionally, the full seed percentage shown on a germination report will be different from the full seed percentage given on an X-ray report for the same lot. This may also occur between two germination tests performed on the same lot. A small difference is due to chance, better known as sampling error, because the X-ray analysis and the germination tests are conducted on two separate samples. This splitting of the sample is done to speed the testing process by allowing both tests to be conducted at the same time. The X-ray test would have to be completed before starting the germination test if only one sample were used, and thereby delay the final results. Completely identical subsamples are rare, so small differences occur. The full seed percentage is determined by cutting the seed remaining at the end of the germination test whenever an International Seed Testing Association (ISTA) certificate is being issued or when the germination percentage is larger than the full seed percentage determined by X-ray. When one of these situations exists, the chance variation among the subsamples can lead to two different full seed values. If they are significantly different, a retest is made.

The Value Of A Quick Viability Test

The three common tests are **excised embryo, tetrazolium**, and **X-ray analysis.** Each has limitations, but all involve a subjective evaluation.

Excised embryo.--This test requires removal of the embryo from the seed. The embryo is then grown on blotter or cellulose paper for about 15 days and an evaluation made. This technique will not work with all species, but it will reduce the testing of western pines from 90 days to about 10 days.

Tetrazolium.--This test is an indirect measure of viability. It is performed by measuring the chemical reaction of an enzyme and tetrazolium to form a red stain. Tests can be completed in 2 to 5 days depending on the species. Certain types of damage can be identified, but it is also possible for the seed to stain and be dead. The test is useful for shrub seed and pine seed when time doesn't permit further analysis.

X-ray analysis.--Evaluation of the internal structure of seed provides a quick and accurate measure of seed development, insect damage, insect infestation or mechanical damage. The analysis requires less than 1 hour. Viability can be estimated from the radiograph of fresh collected seed only. Necrotic areas which cause weakness and death in seeds during storage cannot be identified with X-ray without the use of a contrast agent. A suitable contrast agent has not been found for most species.

When applied by a skilled analyst, quick tests can provide valuable information on seeds when time is limited. Examples include: having to sow seed immediately after it is received from the processing plant or when seed must be used immediately to replace damaged or destroyed seed beds. These results are more variable and therefore are not as accurate as a germination test. Quick tests are not recommended for use when buying or selling tree seed.

Low Seed Viability

Germination reports which are below 50 percent should attract the seed manager's attention to the need to examine the seed lot for the possible causes of the low germination. The cause may be empty or insect-damaged seed and the solution may be to reclean the seed. Recleaning will not always improve germination. If seed are filled, but dead, it is difficult to separate the living and dead seed. If this is the case, it may be wise to discard the seed.

Weak or insect-damaged seed provide a host for several fungal organisms. A direct relationship has been noted between the amount of seed bug damage in southern pine seed and fungal growth in germination tests. If some of these seed are supporting pathogenic fungi, such as the damping-off organisms, and the seed are sown in treated nursery beds, you will be reinoculating the sterilized seed bed.

Actual Germination vs Full Seed Germination

Germination reports from the Eastern Tree Seed Laboratory give two germination figures. Midway on the right side of the test sheet is the actual germination. This is the average number of seedlings produced per 100 seed from the submitted seed sample. This figure is used to estimate sowing rates or determine the value of seed in commercial transactions.

At the bottom of the test report is another germination percent. This is the germination of only the filled seed (often referred to as full-seed germination). This figure represents the potential value for actual germination if all empty seed were removed. Use this figure to compare two lots, as shown in the following example:

	Lot 1	Lot 2
actual germination	86	94
percent filled seed	88	98
full seed germination	98	96

In the example above, Lot 2 appears to be better than Lot 1 (94 vs 86) on the basis of actual germination. However, Lot 1 has 12 percent empty seed. If the empty seed are removed so only potentially viable seed are compared, there is not much difference between the two lots; but note that Lot 1 has more viable seed (98 vs 96 percent).

The full-seed percent may also be used to calculate a new actual germination if you reclean the seed before planting them. If Lot 1 were stratified in moss and then blown dry, many empty seed would be removed with the moss. For new, actual germination percent, cut 1,000 seed and calculate a new filled-seed percent. (Let's assume 960 were filled out of 1,000 seed; thus 96 percent are filled.) Multiply the full-seed percent by the new percent of filled seed (98 x .96 = 94 percent). The new actual germination would be 94 percent for Lot 1 upon the removal of the empty seed.

Upgrading Seed

Remove empty or partly filled seed to improve the germination of the remaining seed--but don't stop there. A factor often overlooked is purity. Impurity or trash adds to storage volume and thus is costly. Some trash, such as seed wings, hold high percentages of water. As the moisture in stored seed equalizes in sealed containers, the filled seed will absorb some of the moisture from the trash and thereby slowly increase in moisture content.

Purity is measured as a percentage of the weight; thus a 90 percent purity indicates that 10 percent or 10 pounds of a 100-pound lot, is trash. That's a lot of trash if it is broken wings, dust and cone scales, but is not very much if it is resin particles because they are very heavy. Either type decreases uniform seedling density by reducing the precision in seed sowing. This reduction is not necessary because both types of debris can be removed during the seed processing operation.

Adverse Effects Of Stratification

Occasional adverse effects of stratification used to be observed in shortleaf pine. In more recent years this phenomenon has been observed in many other coniferous species. The cause has not been identified.

The result, however, may be interpreted as an identification of a seed weakness. When the weak seed are put under the stress of stratification weaknesses are exaggerated. Such seed are no longer capable of germination and sometimes become the host of fungal organisms. Detecting weakness, as well as dormancy, is one of the benefits of paired germination tests. When seed in the stratified test germinate far worse than those in the unstratified test a weakness is present. This seed may do reasonably well in a nursery if all conditions are favorable; but if adverse weather occurs, the field germination will be low. A compromise may be achieved in the nursery by planting the seed after a 24-hour water soak in lieu of the stratification. Field germination was not as uniform, but total germination was found to be greater in trials using the 24-hour soak in a Georgia State nursery.

Request Appropriate Tests

For a number of years, seed managers have been able to request only the seed tests they actually needed. This has worked well, saving time and money for both the seed manager and the laboratory. The Laboratory wishes to encourage inquiries about test requests from cooperators so that Laboratory personnel may help them obtain only the needed tests. Interaction between the requestor and the laboratory is maintained even after tests are received. For example, in 1978, a longleaf pine sample was received with a request for a tetrazolium test. However, the X-ray analysis that is done before the tetrazolium test showed the seed was of low viability. In consultation with the seed manager the decision was made not to spend the time and money on the tetrazolium test. That lot was not worth the cost for additional testing.

Consequences Of Uncontrolled Testing

The consequence of conducting a germination test under improper conditions is illustrated by the following incident, in 1976. A sample of eastern white pine was received at the Laboratory with a report that the seed germinated only 4 percent without stratification and 0 percent with stratification, in a test made at the nursery. "What was wrong with the seed?," the nursery manager asked. In the tests at the Laboratory, germination without stratification was 83 percent, and 92 percent with stratification. The ideal test conditions at the Laboratory made the difference. Proper equipment must always be used if accurate results are to be obtained. Had the nursery manager believed his own data, he might have thrown away hundreds of dollars worth of seed or disastrously over-sown the nursery. If you wish to test your own seed, that's fine. But, please, contact the Eastern Tree Seed Laboratory or the State AOSA Laboratory for information on proper equipment and techniques.

Overheating In Seed Storage

The effect of increased temperatures on stored seed depends on several factors: actual temperature, duration, condition of the seed and seed moisture content. Healthy dry seed that is in properly sealed containers should be able to survive short periods of temperatures as high as 130° to 140°F. The lethal temperature limit for most tree seed is about 150°F, but the effect on the seed is related to a combination of temperature and moisture content. Moist seed cannot tolerate temperatures above 40°F for long because of increased respiration. These seed will either germinate or deteriorate.

Some problems reported to the laboratory which would relate to overheating are: the storage plant burning down or long distance shipping of seed on a hot day. There are no clear cut guidelines except to sample the potentially damaged material and request test data. Be sure to mention the suspicion of heat damage so an indepth evaluation can be made.

Heat by itself has only slight effects on dry seed, if below 150°F. Damage to the seed increases as moisture content and duration increase, but is magnified as seed vigor is decreased.

Sowing Without Test Data

Occasionally, the nursery manager has small (less than 10 pounds of southern pine) lot of seed to sow. Before requesting a test, some considerations should be given to the importance of the seed lot. If the seed is old or considered relatively low in value, a radiograph may be sufficient. This would provide a measure of the maximum potential germination, which may be adequate because the seed cannot be sown uniformly.

On the other hand, if the seed is considered of high value and one desires to obtain every plantable seedling, a small test sample of about 100 seeds should be submitted for the radiograph. The same seed can be used for the subsequent stratification test. This test procedure could be requested at a reduced cost. In the past, radiographs requested for small lots have shown that the results provide reasonable field expectations. This technique loses accuracy, however, as the seed lot is increased.

A Review Of The Seed Testing Service

Data from service testing for 1955, 1960 and 1976 are summarized in table 1 to show changes in the service program in the first 25 years of work at the Laboratory.

Service test requests grew from an initial few States to service for the entire South and then the Eastern United States. With this expansion came an increase in the number of species tested and a decrease in the size of the seed lot. The promotion of better seed processing led to an increase in seed viability (table 2).

Table 1.--Summary of three selected years from service test data.

Item Measured	1955 (yr. 2)	1960 (yr. 7)	1976 (yr. 23)
Number of species	10	16	72
Number of States participating	8	15	29
Number of seed samples	296	341	2146
Tons of seed represented by test samples	137	111	200
Average lot size (pounds)	923	653	186
Overall avg. germination (percent)	52	73	67
Avg. germ. of filled seed (percent)	80	80	70
Avg. purity (percent)	96	98	86
Avg. number of seed per pound	15,550	17,570	28,374
Number of paired tests	105	175	743
Number of species with more than 10 tests	3	5	24

Table 2.--Summary seed testing results for the three leading species at the Eastern Tree Seed Laboratory.[1]

	Species	Actual germination	Germination of filled seed	No. samples tested
1955:				
	Slash pine	67	85	103
	Loblolly pine	43	74	95
	Longleaf pine	41	84	30
1960:				
	Slash pine	78	81	122
	Loblolly pine	77	84	115
	Longleaf pine	64	76	51
1976:				
	Douglas fir	86	86	522
	Loblolly pine	78	78	502
	Slash pine	73	79	206

[1] These results show the progression to better and cleaner seed over several years.

Further evaluations are made with respect to seed dormancy. These evaluations were not made in 1955 (see table 3), but have become an important part of determining the value of the seed for both sowing and selling purposes.

Table 3.--Summary, paired tests showing the effects of stratified vs nonstratified treatments, 1955, 1976.

Species	Total No. paired tests	No. lots Showing Effect of Stratification			Avg. Germination	
		+	0	-	Unstrat.%	Strat.%
1955:						
Loblolly pine	77	24	49	4	81	84
Slash pine	76	4	56	16	83	81
Shortleaf	9	3	6	0	73	77
E. White pine	8	7	1	0	59	76
1976:						
Loblolly pine	288	107	23	158	75	78
Douglas fir	144	21	112	11	78	80
Slash pine	38	21	16	1	66	72
White fir	36	15	20	1	48	53
Silver fir	31	15	14	2	42	47
Noble fir	31	2	21	8	27	26
Englemann spruce	29	0	11	18	68	61
Red fir	21	1	15	5	26	24

Points of interest include: (1) in recent years, more lots of loblolly pine respond unfavorably to stratification, (2) although often requested, Engleman spruce does poorly when stratified, and (3) some species, such as red fir, noble fir, Douglas-fir and slash pine are not usually affected by stratification, either favorably or unfavorably.

Summary of 1977-78

The number of seed samples tested has steadily increased since 1972. In both 1977 and 1978, 3,320 samples were received for germination tests. This is a 16 percent increase over 1976. The increasing number of test samples required some organizational and procedural changes for more efficient handling. Computerization helped meet the expanded clerical load. As samples were received, test request data was keypunched. This data was then used to prepare computerized invoices.

During the 1977-78 testing season, more than 20,000 background tests were made on 84 species for 98 different customers from 42 States.

Fig. 1.--Dewinging small seed lots can be difficult. Wet dewinging can be accomplished by applying a fine spray of water to absorb the moisture, light rubbing of the seed by hand and then blowing the debris away.

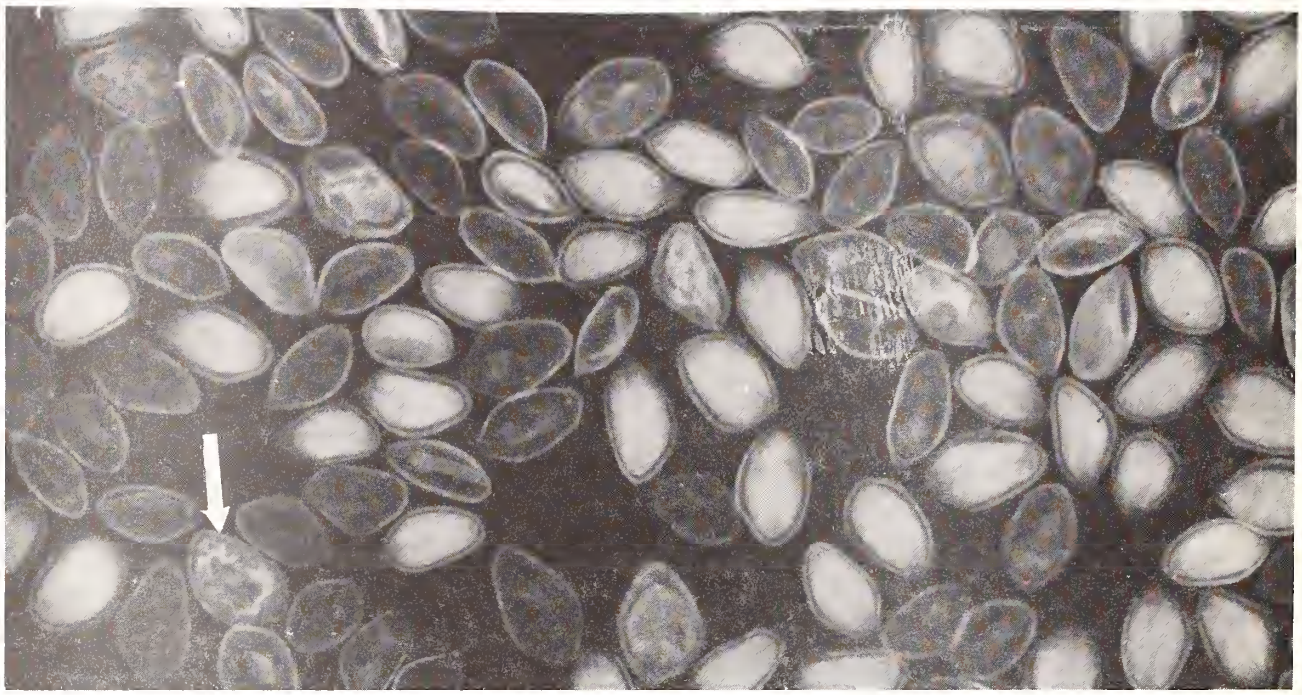

Fig. 2.--An increasing problem with slash pine seed is fungal infection (see arrow) as pictured here.

U.S. FOREST TREE SEED CENTER

The Tree Seed Center serves as a central facility for coordinating seed requests from foreign researchers. A clerical position was established and filled in July 1976, and a technician position in June 1977. These positions permitted a tremendous backlog of requests to be processed.

During this 2-year period, the Seed Center filled over 200 requests from more than 70 countries. These requests resulted in the shipment of more than 1,300 individual seed samples representing more than 100 species. These requests were sent to the Center from Federal, State and private industry as well as individual foreign labs and FAO representatives. In addition to these seed shipments, the Seed Center assisted several private industries and research facilities in shipping more than 4,000 scions (cuttings) to Africa and Europe. An additional 53 requests were directed to commercial sources because of the lot size and species requested. More than 200 replies to requests for technical information were sent along with reprint material.

The Tree Seed Center began operations with an inventory of 788 known source lots. A total of 174 lots were closed and 233 new ones added, bringing the current inventory to 847 known source seed lots in the United States. These lots represent 74 species.

RESEARCH

More than 1,100 tests were made to complete formal studies and informal investigations. Because many of the informal investigations will not be published formally they are worth mentioning here.

Fungicide Treatment

Objective.--To evaluate the influence of the length of time of treatment of a bird and rodent repellent, Arasan 42-S, on germination.

Method.--Arasan 42-S was applied to the seed of six lots of longleaf and four lots of slash pine selected from the testing program. The Arasan was rinsed off with running tap water after 10, 60 and 240 minutes of treatment. A non-treated control was also rinsed with each treatment.

Findings.--Germination was increased by rinsing the Arasan from the seed after 10 or 60 minutes, but not after 240 minutes. Germination increased from 13 to 20 percent. A complete explanation is not yet available, but it was noted that germination was improved significantly by a water rinse over that of dry seed. The reason seems to be the removal of fungal spores which adhere to the seed coat. In fact, these preliminary trials indicated that a water rinse was as effective in reducing seed mold as was a fungicide. However, fungicides are still necessary on seed beds to protect the seed from extraneous spores and fungal hyphae.

Effect Of Gibberellic Acid (GA) On Conifer Germination

Objective.--Evaluate the effect of various concentrations of GA on germination of slash, loblolly and eastern white pine and eastern larch.

Method.--Three replicates of 100 seed each were soaked in 10 ppm and 150 ppm GA solutions overnight, at room temperature. The seed were then germinated in the standard manner. A water soak was used as the control with a non-soaked test.

Findings.--No significant differences were observed in germination percent or germination speed.

Effect Of Substrate Moisture On True Fir Germination

Objective.--Evaluate the effect of various levels of the water-holding capacity of the substrate on the germination of selected true fir seed.

Method.--Six species of true fir (balsam, shasta red, white, noble, pacific silver and subalpine) were germinated on seven levels of substrate moisture (10, 23, 36, 49, 62, 75, and 88 percent of water-holding capacity). Four replicates of 100 seed each were germinated on cellulose paper under standard, controlled conditions.

Findings.--All but noble and white fir showed a wide tolerance to substrate moisture. Both white and noble fir showed an intolerance to high levels of substrate moisture. The optimum levels of substrate moisture in these trials were:

Species	Percent
Balsam fir	36-75
Shasta red fir	36-88
Whtie fir	36-49
Noble fir	23
Pacific silver fir	49-62
Subalpine fir	36-88

Running vs Standing Water Soaks

Objective.--To see if running water is more beneficial than standing water and if muslin bags are more beneficial than plastic bags on seed viability in stratification preparation.

Method.--Four replicates of 400 seed each of two loblolly pine and one Douglas-fir seed lots were subdivided for the following treatments: (1) 24-hour soak in standing water followed by stratification in plastic bag, (2) 24-hour soak in standing water followed by stratification in cloth bag, (3) 24-hour soak in running water followed by stratification in plastic bag, and (4) 24-hour soak in running water followed by stratification in cloth bag.

Findings.--Total germination was not affected by any treatment; however, the rate of germination did show a response (table 4). The drying effect in cloth bags delayed the germination of both loblolly pine seed lots, but did not have any consistent effect on Douglas-fir seed. These results would suggest that drying of loblolly pine seed during stratification could delay field germination, but would not affect the total germination. However, total germination might be reduced if subjected to an environmental stress because of the delay in germination speed.

Effect Of Light On Eastern Redcedar Germination

Objective.--This species is usually germinated without light. Because the evaluation of light had not been made in a long time, this study was conducted to determine if light is necessary.

Method.--Six samples of redcedar were taken from the Laboratory stores. Eight random subsamples of 100 seeds each were selected for each lot. The samples were stratified for 30 days and then divided into two treatments to be germinated at 15°C. One set of 4 x 100 seed were germinated with the standard, continuous light of a cabinet germinator in clear germination boxes while the other 4 x 100 seed were placed in black, light proof germination boxes.

Table 4.--Summary, total germination and rate of germination of three lots of seed soaked in standing or running water and then placed in plastic or cloth bags before stratification.

Seed Lot	Treatments			
	#1 Standing Water Plastic	#2 Standing Water Cloth	#3 Running Water Plastic	#4 Running Water Cloth
	- - - - - - - Germination percent - - - - - - - - -			
Lob #1	95	96	96	96
Lob #2	73	70	66	76
Douglas-fir	97	97	98	95
	- - - Days to reach 50% of total germination - - -			
Lob #1	12	17	12	17
Lob #2	11	13	12	15
Douglas-fir	13	11	11	11
	- - - Days to reach 90% of total germination - - -			
Lob #1	19	23	20	21
Lob #2	18	21	20	25
Douglas-fir	18	17	19	20

Findings.--The average germination was reduced from 57 percent to 46 percent, and the rate of germination was slowed by 6 days in the dark. Previous germination tests did not have the precision of temperature control used in these tests. Therefore we might conclude that with precise temperature control, light can become a promoting factor. Without this control, light is not as critical. Thus, testing laboratories should not only be aware of this requirement, but practice these techniques to provide nurserymen with reliable, repetitive results.

Effects Of Freezing On Freshly Sown Seed

Objective.--Identify whether freezing temperatures are detrimental to fully imbibed or stratified seed.

Method.--Random samples of 600 seed were drawn from two lots of each of eight species (longleaf, slash, Virginia, Scotch, shortleaf, loblolly and eastern white pine and Englemann spruce) plus one lot of red pine for each treatment. The longleaf samples were soaked overnight in water while the slash, Virginia and Scotch pine were stratified for 15 days. The remaining species were stratified for 30 days. Following these treatments the seed were divided into four replicates of 50 seeds each per temperature treatment. The longleaf temperature treatments were: (1) control, (2) 4 hours at -7°C after 2 days in germination chamber and (3) 22 hours at -7°C after 4 days in germination chamber. The temperature treatments were: (1) control, (2) 4 hours at -7°C following stratification and (3) 4 hours at -7°C after 4 days in the germination chamber.

Findings.--All treatments at -7°C solidly froze the Kimpak (germination media). Germination of Scotch, Virginia and longleaf pine seed were reduced by exposure to as little as 4 hours (22 hours for longleaf) of freezing temperatures after germination had been initiated. They were not affected by freezing prior to that even though the seed were fully imbibed (table 5). Slash pine germination was reduced by freezing while fully imbibed and further reduced by freezing following the initiation of germination. Other species were not affected. This data suggests most species could be sown without damage if an overnight freeze were to occur, except slash pine.

LABORATORY PARTICIPATION AND COOPERATIVE ACCOMPLISHMENTS

International

The Laboratory was represented at the International Seed Testing Association Conference in Madrid, June 1976, where the Laboratory Director was named vice chairman of the Forest Tree Seed Committee. Laboratory personnel are helping to prepare an Abnormal Seedling Evaluation Handbook that will include tree species.

The Laboratory hosted an International Workshop on Estimating Seed Viability, May 1978. The workshop was attended by 33 participants from 13 countries and 12 States in the United States. The attendees went to Starkville, Miss., following the workshop, for a symposium on tree seed.

Table 5.--Summary, germination of fully imbibed and stratified seed subjected to freezing.

Species	Treatment[1]		
	A	B	C
	- - - Average germination percent - - -		
Longleaf pine[2]	80 a [3]	78 a	31 b
Slash pine	68 a	60 b	55 c
Virginia pine	88 a	87 a	74 b
Scotch pine	66 a	68 a	40 b
Shortleaf pine	70 a	66 a	67 a
Red pine	97 a	96 a	97 a
Loblolly pine	68 a	64 a	67 a
Englemann spruce	68 a	64 a	67 a
Eastern white pine	72 a	78 a	76 a

[1]Treatments apply to all species except longleaf pine. Treatment A is the control; seed in treatment B was held 4 hours at -7°C following stratification; seed in treatment C was held 4 hours at -7°C, after 4 days in the germination chamber.

[2] Longleaf pine seed were soaked in water overnight, instead of stratified. Longleaf seed in treatment B was held 4 hours at -7°C after 2 days in a germination chamber; longleaf seed in treatment C was held 22 hours at -7°C, after 4 days in germination chamber.

[3] Figures with different letters are significant at the 0.01 level of probability.

National

The Laboratory was represented at the annual Association of Official Seed Analysts meeting, June 1978, Lincoln, Neb. The Association formed a new committee on browse-shrub and forbs and appointed the Laboratory Director chairman. The Laboratory Director and Dr. J.A. Vozzo (Southern Forest Experiment Station) are preparing an X-ray handbook for AOSA.

Regional

Laboratory personnel participated in the Forest Genetics Workshop and the Pine Pollen Management Meeting. The latter group will prepare a pollen management guide.

Personnel

After 20 years of service, Mrs. Ida Mae Moseley, better known as Macy, retired. Macy began her seed technologist career as a temporary employee under the supervision of Tom Swofford. She was employed by the Georgia Forestry Commission as a Germination Analyst but, to many nurserymen, she was the gifted caretaker of their seed samples. Macy was the first employee to ever retire from the seed laboratory.

For those using the services of the U.S. Forest Tree Seed Center, Mr. Frank Brown, technician, will now receive and process the seed. Frank transferred to the Laboratory from the Southern Forest Experiment Station. Questions on international customs regulations will be answered by Mrs. Jane Batchelor, clerk for the Seed Center. Jane transferred to the Laboratory from USDA's Animal and Plant Health Inspection Service.

The increased work load at the Laboratory was partly relieved by help from the YACC (Young Adult Conservation Corp) program. The Laboratory was granted three positions in 1977 to provide support service for the Laboratory. The Laboratory has employed the second YACC employee in the nation. YACC enthusiasm and ability have helped the informational assistance program considerably.

SEED ORCHARD MONITORING

In the 20th Report from the Laboratory, a summary of the results from the first 2 years of Seed Orchard Seed Evaluation Testing (SOSET) and the first year of the Cone Analysis Service (CAS) were reported. SOSET provides a quality evaluation of the seed extracted following a normal drying routine. CAS gives a detailed analysis of seed production and estimates the seed production capacity of individual cones. More details on these procedures are available in the 20th Report and from two references listed in the bibliography of this report (Bramlett, et al, 1978, and Karrfalt, 1977).

SOSET continues to be useful to forest seed orchard managers. The demand for this service has remained relatively constant. CAS, on the other hand, has shown a steady increase. In 1976, 1,246 cones were analyzed. Using the number of requests received in 1976 as a basis, there was a 9 percent increase in requests for the service in 1977 and a 55 percent increase in requests in 1978.

Samples were received from State, private and Federal sectors. Laboratory personnel have helped a few organizations to establish their own cone analysis facilities. X-ray analysis has been performed for several orchards that planned to do their own CAS work, but lacked X-ray equipment.

The species analyzed were Virginia pine, longleaf pine, slash pine, shortleaf pine and loblolly pine. Their respective seed production capacities, averaged over all samples received, are 92, 148, 184, 98, and 152. There appears to be some variation (see table 6). Eastern sources consistently had higher seed production capacities than western sources of loblolly pine.

Table 6.--Summary of the 1977 and 1978 Cone Analysis Service.[1]

Slash measurement	Longleaf GA-FL	Longleaf NC	Virginia VA-NC	Shortleaf NC-SC	Loblolly pine NC	Loblolly pine SC	Loblolly pine AR	Loblolly pine OK
Total cones evaluated	185.0	88.0	188.0	217.0	745.0	577.0	177.0	302.0
Average 12.3 length (cm)	15.6	5.8	5.6	10.2	9.8	8.4	8.1	---
Average 45.6 weight (gm)	7.9	8.3	6.0	27.3	20.3	21.0	18.4	---
Number of scales:								
Lower infertile	69.0	84.0	54.0	40.0	52.0	56.0	48.0	48.0
Fertile 92	74.0	46.0	49.0	82.0	79.0	69.0	74.0	---
Upper infertile	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Seed potential	184.0	148.0	92.0	98.0	164.0	158.0	138.0	148.0
Extracted seed:								
Number 106	60.0	58.0	28.0	113.0	68.0	59.0	40.0	---
Percent sound	77.0	70.0	52.0	47.0	85.0	62.0	74.0	70.0
Dissected seed								
Number 14	8.0	12.0	13.0	16.0	21.0	41.0	28.0	---
Percent sound	57.0	40.0	38.0	31.0	75.0	41.0	68.0	61.0
Total sound seed	90.0	52.0	44.0	32.0	108.0	47.0	72.0	46.0
Percent remaining	10.0	9.0	13.0	12.0	12.0	31.0	40.0	37.0

[1]Means are presented with the deviation between years. (only sources that appeared during both years are shown.)

Most cones contained some seed even when totally opened, but the seed remaining was of a lower quality than that extracted. The ratio of filled to empty seed was also less with the seed remaining in the cone than it was with the extracted seed. There was, however, sufficient seed remaining in the cones so that, if the cones were ground in a hammermill, the resulting material could be used to reclaim spoil banks. The addition of a desirable grass seed to the ground pine cone material would meet spoil bank requirements and use a routinely discarded material.

A further analysis of these cones was made by selecting 27 cones in each of three seed production levels. The seed production levels were arbitrarily set at 0-50; 60-100 and 120 plus extracted seeds per cone. This permitted distinct categories. The data (table 7) show the seed production capacities to be the same (83) for all levels, while the total extracted seed was very different. Although the number of seed extracted from each category ranged from a low of 27 to a high of 143, the percentage of filled seed was nearly the same in all production levels both for the extracted seed and total seed produced. In the lower production levels, more filled seed remained in the cone. The data suggest that low seed production observed in these samples was mostly the result of poor cone opening. Although a real difference of nearly 2 to 1 was observed in total seed produced between the low and high levels (75 and 146 respectively) the data suggests a lack of seed development rather than insect problems.

A more detailed analysis of the seed losses was also made for the loblolly pine examined each year (table 8). The data show that most of the seed production capacity is lost because of first year abortion and to developed, but empty seed coats. Entomologists with the Southeastern Forest Experiment Station and the Forest Insect Disease Management Staff of the Forest Service's Southeastern Area, State and Private Forestry have shown that these two categories are largely caused by insect feeding, primarily the seed bugs (Leptoglossus and Tetrya).

Table 7.--Summary of CAS measurements for 27 cones in each of three seed production categories.[1]

Measurement	Seed production categories High	Medium	Low
Number fertile scales	83 ± 7.9	83 ± 15.5	82 ± 12.6
Total seed extracted	143 ± 14.9	82 ± 10.8	27 ± 10.6
Percent potentially sound	79	80	74
Total seed dissected	3 ± 3	49 ± 32.9	48 ± 42.8
Percent potentially sound	67	83	73
Total seed produced	146 ± 28.2	131 ± 34.3	75 ± 41.7
Percent remaining in cone	2	38	64
Percent potentially sound	79	82	73

[1]Means with one standard deviation. Selections were made as follows: high = 120 + seed, medium = 60-100 seed, and low = 0-50 seed.

Table 8.--Summary of seed evaluation in the cone analysis of loblolly pine.

Measurement	1977	1978
1st year ovule abortion*	40	30
2nd year ovule abortion*	2	1
Definite insect damage*	1	0
Empty seed*	15	20
Potentially sound seed* (seed production efficiency)	41	49
Other*	1	0
Total per cone	100	100
Extraction efficiency (percent)	67	83
Full seed germination (percent)	96	97
Seedling efficiency* (sound seed producing seedlings)	39	47

*Values given as percent of seed production capacity.

Moisture Meters For Tree Seeds

For several years, forest nurserymen had assurance that the Radson moisture meter would serve their purpose. Then it became the Dole meter. First, it was a 200 model, then a 300 model, and now a 400. However, the new 400 model will not work with forest tree seed. The unit was adapted for use with agricultural seeds and because of the high demand from those sources, the company made the model 400 with an internal balance.

The recommended replacement is model PB-71; but, to ensure the correct meter is sent, indicate in the order that it is to be used for forest tree seed. This moisture meter is known as the "Red Line" meter, in agriculture. The meter is produced by Gilmore-Tatge at Clay Center, Kansas, and uses the same moisture charts produced for the Dole 200 and 300 meters. It is available through:

Eaton Corporation
Controls Division
191 East North Ave.
Carol Stream, IL 60187
ATTN: Mr. Jim Model
Phone: (312)682-8000

If you have a model 400-B, contact Mr. Model for an exchange.

Seed Treating

Seed World magazine (Feb. 1979) described a new piece of equipment of interest to forest nurserymen. The Gustafson S-600 SS commercial seed treater reportedly can treat up to 550 bushels of small grain seed per hour for any formulation, including solutions and wettable powder slurries. Optional attachments allow application of "two or more formulations simultaneously regardless of whether they are fungicides, insecticides, liquids, wettable powders or dust treatments."

The machine is about 6 feet long by 10 inches wide by 30 inches high. It is made of corrosion-resistant, stainless steel for easy clean-up. For more information, write: Gustafson, Inc., 6350 LBJ Freeway, Suite 180, Dallas, TX, 75240. At this time, we know of no one who has tried this equipment.

Tree Seed Dewinger

A new dewinger has been designed by the Forest Service's Missoula Equipment Development Center. The MEDC dewinger is a rubber-lined cylinder with a rotating central shaft powered by a variable-speed motor. Complete drawings are available on request from Ben Loman, USDA Forest Service, Equipment Development Center, Fort Missoula, Building 1, Missoula, Mont. 59801. It is also commercially available from Wilkins and Associates, Inc., 601 Alexander Ave., Tacoma, Wash. 98421, and Gentry Machine Service, Box 263, Carson, Wash. 98610. The cost is $3000 to $4000. The Eastern Tree Seed Laboratory dewinged several trial samples of seeds on the prototype and found it very successful.

Ringing Aids Germination

In keeping up with the field of seed handling, we often find ourselves going from the sublime to the ridiculous. Therefore, take this bit of information for what it is worth. We want to thank one of our closest friends for alerting us to this information.

B.F. McLemore reported in Forests And People magazine on a study in India that found that the sound of electric bells causes some seeds to germinate faster. Tapioca and sweet potatoes showed a 40 percent increase in yield when subjected to recorded music during the growth cycle. Rice and tobacco grown with musical accompaniment yielded 50 percent increases. Dr. Singh of India explains, "the vibrations in the plant cell agitate the sensitive protoplasm and nuclei in such a way as to accelerate growth." We don't know anyone who has tried it with trees, but we did hear that the fuming of one nurseryman may have been the cause for reduction in weed growth.

REPORTS FROM PARTICIPATING CO-OP FORESTERS

Nursery/Tree Improvement Specialist

The Nursery/Tree Improvement Specialist for the Forest Service's Southeastern Area, Dr. Clark W. Lantz, is stationed at the Area Office (1720 Peachtree Rd., NW, Suite 300, Atlanta, Georgia 30367, Telephone [404]881-3611). Clark maintains close liaison with the Laboratory for the operation of the Forest Reproductive Materials Clearinghouse as well as workshops and short courses.

The Forest Reproductive Materials Clearinghouse provides a means for buyers and sellers of seeds, seedlings, cuttings, cones, or pollen to get together for their mutual advantage. This service is available weekly from November 1 to March 31, and once during the summer. If you wish to use the service, simply write or call the Eastern Tree Seed Laboratory at (912) 744-3311. All entries received by Thursday of each week will appear in that week's Clearinghouse, which is mailed on Friday. Notice of the summer issue is sent to all subscribers so that fall seed requests may be listed. In the past two years, more than 140 individual requests for seed or seedlings were sent via the Clearinghouse to more than 100 participants.

1978 Nursery Conferences

The 1978 Southeastern Area Forest Tree Nursery Conferences were held in Hot Springs, Ark., (July 24-27) and Williamsburg, Va., (August 7-10). The western session (Hot Springs) was attended by 74 persons and featured a field trip to the Arkansas Forestry Commission, Bluff City nursery and seed orchard, and the Weyerhaeuser nursery and seed orchard at Magnolia. A total of 124 persons registered for the eastern session (Williamsburg), which included field trips to the New Kent nursery and seed orchards of the Virginia Division of Forestry and optional trips to Carter's Grove Plantation and Yorktown National Park. Information presented at this conference appears in a published proceeding. Although the supply of copies is exhausted, you may examine a copy in a library, State forestry agency, or this Laboratory.

1980 Nursery Conference

The 1980 Forest Tree Nursery Conference is planned for Lake Barclay, Ky., as a joint (east and west) session.

Southeastern Area Forest Tree Nursery Handbook

Dr. Jack May has been awarded a USDA Forest Service contract to write a Southeastern Area Forest Tree Nursery Management Handbook. The manual will include contributions by Dr. Earl Belcher (seed handling), Dr. Dean Gjerstad and David South (weed control), and Drs. Ed Cordell, Ted Filer and Jim Rowan (disease control).

Arasan 42-S

For a number of years, Arasan 42-S has been the only EPA-registered bird and rodent repellent available for the treatment of southern pine seed. DuPont stopped making Arasan 42-S, but the chemical is available under the name "Gustafson 42-S". It is available from International Forest Seed Company, P.O. Box 76008, Birmingham, Ala. 35223 (phone [205]595-2565).

Anthraquinone

Anthraquinone is an effective bird repellent, but it is not registered by EPA for this use.

Possible sources of Anthraquinone for experimental use are:

J.F. Henry Chemical Company, Inc.
245 Park Avenue
East Rutherford, NJ 07073
(201)939-7100

Mobay Chemical Corporation
Industrial Chemicals Division
Pennsylvania Lincoln Parkway West
Pittsburg, PA 15205
(412)777-2510

Endangered Species Specialist

A new position, Endangered Species Specialist, has been established in the Forest Service's Southeastern Area. Dr. Andrew F. Robinson, a professional botanist, is the first incumbent in this position. He provides technical assistance on threatened and endangered plant species to 13 State forestry agencies plus other forestry species. Dr. Robinson is negotiating a Memorandum of Agreement among the Georgia Department of Natural Resources, the Laboratory and the Forest Service's Southeastern Area to concentrate propagation efforts toward three protected plant species: hairy wild indigo, persistent trillium and Florida torreya.

Investigations are already underway on collection techniques, storage, viability, germination and growth requirements of the seeds from these three protected plants. Dr. Robinson is evaluating the effect of bedding on the continued growth and development of hairy indigo in pine flatwoods of southeastern Georgia. Initial observation indicates that if bedding is done on 12-foot intervals, some plants will remain. However, many of the plants occur within 2 feet of the windrow created by K-G blading and thus, if this area is not bedded, a significant number of the plants will not be damaged. Species description-management guides for 65 of the proposed endangered southeastern forest-related species will be available early in 1979. Work is planned for other protected plant species as time and funding allows.

(Note: Dr. Robinson transferred to another agency before this report was published. In the interim, until a successor is hired, information on work concerning endangered species may be obtained from Robert G. Hitt, Staff Director, Special Forestry Services Staff, USDA Forest Service, Southeastern Area, 1720 Peachtree Rd., NW, Suite 300, Atlanta, Ga. 30367

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PART II

TWENTY-SECOND LABORATORY REPORT

Fiscal Years 1979 and 1980

By

Earl W. Belcher

National Tree Seed Laboratory

P.O. Box 819

Macon, Georgia 31298

Operated in cooperation with:

Southeastern Area, State and Private Forestry, U.S. Forest Service;

and the Georgia Forestry Commission.

INTRODUCTION

The Twenty-second Laboratory Report covers a period of great change.

In July 1978, the Georgia Forest Research Council was abolished by the State Legislature and the research appropriations were assigned to the Georgia Forestry Commission. The Seed Laboratory initiated computer invoicing to reduce labor costs at this same time. By July 1979, the Seed Laboratory entered into a new cooperative agreement with the Georgia Forestry Commission. In this agreement, research was deleted and the laboratory building was assigned to the Forest Service by a lease agreement. Plans were begun to expand the physical facilities.

In September 1979, the Assistant Laboratory Director, Robert Karrfalt, took a 1-year leave of absence for advanced training. Then, in October, the Seed Laboratory became a separate unit in Cooperative Forestry. This change added administrative responsibilities and thereby decreased available time for technical assistance to nurserymen.

In November, the laboratory was renamed the National Tree Seed Laboratory to reflect the present scope of work. The competitive demands for computer time made our invoicing revert to manual preparation. Invoices were prepared monthly in 1979-80 to avoid a backlog of data.

By the spring of 1980, the Seed Laboratory expansion became a part of the 1981 budget, and a Forest Service task force was formed to identify the current mission and role of the Seed Laboratory.

This report summarizes the accomplishment of the National Tree Seed Laboratory during the 1979 and 1980 testing season.

SEED TESTING SERVICE

The Seed Laboratory completed nearly 4,800 germination tests per year. The background tests include: moisture content, purity, seeds per pound and full seed percent (see table 1).

Improved seed processing and seed handling could have increased the viable seed available for sowing.

***

Table 1.--Results of background tests for seed germination

Year	Total Tests	percent of total above 9% moisture	percent of total below 95% purity	percent of total full seed % below 95%
1979	4,755	6.2	6.2	27.9
1980	4,264	5.6	2.7	19.8

Samples were received from 93 customers in 35 States in 1979, and 90 customers in 29 States in 1980. The 1979 samples represented 79 species, and the 1980 samples 83 species. The submitted samples represented more than 215 tons of forest seed in 1979 and 424 in 1980.

SEED ORCHARD MONITORING

A total of 4,425 cones were received in 1979 and 3,476 in 1980 for SOSET and CAS analysis. An analysis of the 1980 loblolly data showed that the cones' efficiency was still rising. Improved seed orchard management has raised the cone efficiency to 63 percent.

TREE SEED CENTER

The Seed Center completed 47 requests for 543 seed lots to 54 countries, in 1979. In 1980, 1,024 seed lots were sent to 35 countries, on request. The center also shipped more than 1,200 scions and 450 cuttings to other countries. Several requests were directed to commercial sources. This service has promoted commercial sales for private seedsmen of U.S. forest tree species.

LABORATORY NOTES

Technical Assistance

The Seed Laboratory provided the following services:

***

- Published 19 issues each year of the **Reproductive Materials Clearinghouse**, making buyers and sellers of tree seed aware of needs and availability.

- Held 2-week, specialized courses for seven nursery trainees at the Seed Laboratory during this period.

- Evaluated several processing plants. The evaluations provided alternative solutions to technique, equipment and personal usage.

- Assisted a State processing plant to upgrade seed lots. Some lots were improved as much as 20 percent.

Laboratory Personnel

Robert Karrfalt was transferred to the Seed Center to oversee the operation of the Seed Bank. This left the seed testing service without a supervisor, but the position should be filled soon.

A new clerk was hired for the laboratory. Diann Shave will coordinate timekeeping, purchasing and technical correspondence.

TECHNICAL NOTES

Seed Moisture

Here are two excerpts from Principles and Practices of Seed Storage by L.N. Bass and O.L. Justice (USDA Agriculture Handbook No. 506) which further explain the points we have tried to make.

> The rate of moisture vapor movement between materials and air is determined by the difference in moisture vapor pressure between them. If their moisture vapor pressures are equal, moisture will not move from one to the other.
>
> When moist seeds are placed in a dry atmosphere, moisture will flow from the seeds into the atmosphere. Because the air cannot hold nearly all the moisture held in the seeds, the air will soon become saturated with the moisture given off by the seeds, and unless new dry air is provided, drying of the seeds will stop.

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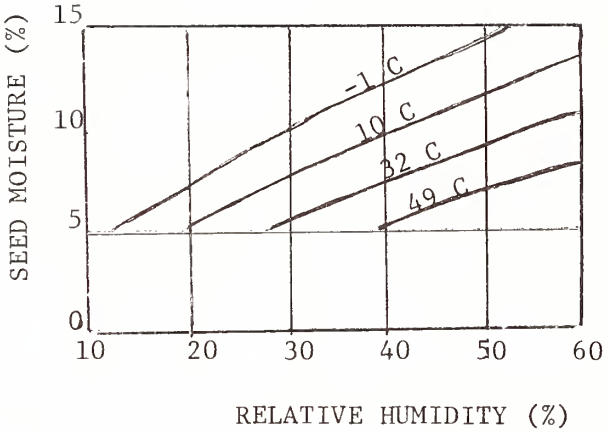

Generally, relative humidities above 55 percent will not permit drying of tree seed. At any relative humidity, increasing the temperature increases the capability of the air to hold water vapor, but once saturated, no further moisture can be removed without changing the air. Therefore, good drying does not require high temperatures, but it does require low relative humidity and good air movement.

Arasan Substitutes

T.E. Campbell, Southern Forest Experiment Station, is evaluating chemicals which might replace Arasan 42-S. Arasan 42-S has become difficult to obtain in the last few years. His early trials look promising. If you need some immediate help with a replacement write to T.E. Campbell, Alexandria Forestry Center, USDA Forest Service, 2500 Shreveport Hwy., Pineville, La. 71360.

Extraction Tests

This is a free service of the Seed Laboratory which may be extremely valuable to a seed processing operation. Samples are collected after the seeds move through each piece of machinery or process, from a single seed lot, with a control from cones as they leave the kiln. Seed Laboratory

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personnel evaluate mechanical damage by radiography and then germinate the seed. A portion of the seed is placed in storage for 6 months and retested to identify impact damage. Table 2 is an example of a report submitted in 1980.

Table 2.--Results of an extraction test

Treatment	Germination of filled seed	Radiograph		
		Empty seeds	Mechanical damage	Other bad seed
	percent			
Drying	92	10	0	3
Scalper	100	17	0	2
Dewinger	64	12	1	6
Cleaning	63	20	1	4

No mechanical damage was visible, but there was sufficient impact damage as the seed were banged around in the dewinger to decrease the seed viability from 100 to 64 percent.

Seed Laboratory personnel provide a report with recommendations to help improve processing.

REPORTS FROM PARTICIPATING FORESTERS

New Nursery and Tree Improvement Specialist

The new nursery and tree improvement specialist in Jackson, MS is John C. Brissette. John is available for technical assistance in the areas of nursery and tree improvement activities in Arkansas, Louisiana, Mississippi, Oklahoma and Texas.

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John is a native of Michigan with the bachelor and master of science degrees from the University of Michigan. He spent 4 years in the U.S. Army, including a tour in Vietnam as a helicopter pilot. Prior to joining the Forest Service, John was a research supervisor with the Michigan State University Cooperative Tree Improvement Program.

John can be reached at the Jackson Field Office, 200 E. Pascagoula St., Jackson, Miss. 39201, phone 601-960-4357.

New Technology Transfer Device

Dr. Frank Bonner, Forestry Sciences Laboratory, Starkville, Miss, has compiled one-page **Current Information Summary** sheets on individual topics. Six of these summaries follow. Contact Dr. Bonner for additional copies (Telephone: 601-323-8162).

No. 1 - Recommended Stratification for Southern Hardwoods.--Seeds sown in the spring normally benefit from cold, moist stratification prior to sowing. Stratification will:

(1) decrease the time between sowing and germination;

(2) widen the temperature range in which germination will occur.

How to do it:

1. Soak seeds in tapwater to increase their moisture content - 24 hours for soft seed coats, 48 hours for hard seed coats and nuts.

2. Pour off excess water and place seeds in polyethylene bags (maximum wall thickness--4 mils).

3. Do not put more than 25 lbs. per bag.

4. Label and place in cooler held at 34° to 40° F.

5. Turn bags over every 1 to 2 weeks and inspect for poor aeration or other trouble.

***

Recommended length of stratification:

sweetgum:	2-4 weeks	sycamore:	none
yellow-poplar:	8-16 weeks	white oak:	none; plant in fall
green ash:	8-12 weeks	*water oak:	8-12 weeks
sweet pecan:	4-8 weeks	**other red oaks:	4-8 weeks

* Use longer periods for northern sources, shorter ones for more southern sources.

** Can also be fall-planted.

For additional information see: Seeds of Woody Plants in the United States. USDA Agric. Handb. No. 450, or contact USDA Forest Service, Southern Forest Experiment Station, P.O. Box 906, Starkville, MS. 39759.

No. 2 - Recommended Storage Conditions for Southern Hardwoods.--The objective of storage is to maintain seed stocks as cheaply as possible until they are needed while loosing as little seed quality as possible. The required storage period or value of the seeds may determine how exacting storage conditions must be. Seeds may also be separated into two groups, based on their physiological characteristics.

***

Recommended seed moisture content and storage temperatures.

Group	Species	Seed moisture	Max. storage temperature		
			Overwinter	2-5 years	over 5 yrs.
		%	degrees C		
I	sweetgum sycamore green ash white ash yellow-poplar black cherry sweet pecan water tupelo	5 to 10	Temp. in °F., plus RH in %, must not exceed 100.	0-5	-18
II	red oaks (water, willow Nuttall, Shumard, cherrybark)	35 to 40	0-5	0-5	currently not probable

For additional information contact:

USDA Forest Service
Southern Forest Experiment Station
P.O. Box 906
Starkville, MS. 39759

No. 3 - Moisture Determination Using Home Microwave Ovens.--For rapid moisture determination of large seeds, microwave ovens can be used. Differences in ovens and settings make calibrations of individual ovens necessary, and it must be kept in mind that results are not as accurate as standard oven methods. Variation can be reduced by preheating ovens prior to measurement.

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Suggested procedures:

1. Draw a sample of at least 10 seeds or fruit.

2. Preheat oven with a dish of water at the center of the oven floor.

3. While oven is heating, quickly break or cut large seeds into fragments no larger than 1/4 the size of intact seeds. Mix and place an amount equal to 5 intact seeds in a tared (weight of container weighed empty) glass container.

4. Record fresh weight to three decimal places.

5. Place container in center of oven when oven floor temperature reaches 60° C.

6. Dry sample for selected time period. While the first sample is drying, draw, prepare and weigh a duplicate sample in the same manner. Check floor temperature before drying second sample (should be 60°).

7. Remove sample and weigh immediately on electric pan balance. If a rapid-weigh balance is not available, samples should be cooled in a dessicator for 30 to 40 minutes before weighing.

8. Calculate the moisture content: seed wet weight - seed dry weight x 100 ÷ seed wet weight.

Typical drying times using General Electric JET 85, or 1 low setting, floor temp. 60° C

Species	Sample weight	Sample condition	Minutes
Quercus shumardii	25 g	cut	4 1/2
Q. nigra	10 g	cut	4 1/2
Carya ovata	20 g	broken	4 1/2
Fraxinus pennsylvanica	3 g	intact	5
F. americana	3 g	intact	5

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For additional information contact:

USDA Forest Service
Southern Forest Experiment Station
P.O. Box 906
Starkville, MS 39759 USA

No. 4 - Guidelines For Measurement of Seed Moisture Content By Oven Drying.--

1. Be sure to mix seed lot well and draw the sample correctly.

2. Put sample in air-tight container immediately.

3. Never expose cold seeds to warm, moist air, as moisture will condense on them. Either take sample in cooler and place in air-tight container, or allow seed lot to reach room temperature before sampling.

4. Do not touch seeds with your fingers unless it is necessary for large seeds. Use spoons or spatulas to transfer samples.

5. Covered containers of glass or non-corrosive metal with rounded sides at the base should be used for drying. They should be large enough to allow no more than 0.3 g/cm^2 of seeds on the dish surface. This rule can be relaxed when drying cut or broken pieces of large seeds because of larger air-spaces between pieces.

6. Seeds longer than 10 mm must be ground or cut into pieces before weighing and drying. Grinding so that 50 percent of the material can pass through a 4 mm mesh sieve is satisfactory unless the seed is oily or high in moisture (above ca. 15 percent). For these cases, cut or break seeds into pieces no larger than 5 to 6 mm in diameter.

7. Allow oven to regain the drying temperature (103° C) after inserting samples before starting the drying time.

8. The space equal to the diameter of a sample container should be left open between containers during drying.

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9. Allow container and sample to cool in a desiccator for 30 to 45 minutes before taking dry weight. With rapid-weight electronic balances in air-conditioned (low humidity) laboratories, the cooling step can be skipped if necessary. It takes about 30 seconds for hot samples to absorb moisture from the air.

10. Take duplicate samples and treat them exactly the same. For large seeds that are ground or cut, two samples must be prepared independently for the duplicates.

For additional information contact: Forest Service, USDA
P.O. Box 906
Starkville, MS 39759 USA

No. 5 - Equilibrium Moisture Contents For Southern Hardwoods.--Seeds stored in unsealed containers gain or loose moisture in equilibrating with the ambient humidity. These equilibrium moisture contents are relatively constant for a given species at a given humidity.

Equilibrium moisture contents at 4-5° C and two relative humidity (RH) levels

Species	40% RH	95% RH
	moisture pct.	
sweetgum	8	20
sycamore	9	21
green ash	8	23
yellow-poplar	10	19
black cherry	9	17
shagbark hickory	10	15
black walnut	11	20
cherrybark oak	10	31
water oak	17	29
willow oak	10	35
Shumard oak	13	32
white oak	37	50

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For additional information, contact USDA Forest Service, Southern Forest Experiment Station, P.O. Box 906, Starkville, Miss. 39759.

No. 6 - Useful Conversion Factors In Seed Work

Seed/weight relationships:

seeds per g = 1000 - weight of 1000 seeds (in g)
seeds per kg = seeds per g x 1000
seeds per kg = seeds per pound x 2.2
seeds per kg = seeds per oz. x 35.2
seeds per pound (lb) = seeds per kg x 0.454
seeds per lb = 453,600 - wt. of 1000 seeds (in g)
seeds per lb = seeds per ounce (oz) x 16
seeds per oz = seeds per g x 28.3
seeds per oz = 1000 - wt. of 1000 seeds (in oz.)

Capacity:

1 liter (l) = 1.06 quart (qt.) (American) = 0.88 qt. (British)
1 l = 0.26 gallon (gal) (American) = 0.22 gal (British)
1 gal (American) = 3.785 l
1 gal (British) = 4.546 l

Seed Drums:

gal (American)	hl (metric)	Capacity, Pinus seed* (kg)
12	0.45	25
24	.91	50
55	2.08	115

Temperature:

°C = 5/9 (°F-32); °F = 9/5 (°C.) = 32

*estimated on basis of *P. taeda* (ca. 40,000 seed/kg)

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